

# 1 RECOMMENDATIONS FOR A COAL MINE DUST STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that occupational exposures to respirable coal mine dust and respirable crystalline silica\* be controlled by complying with the provisions presented in this document. These recommendations are designed to protect the health and provide for the safety of workers exposed to respirable coal mine dust and respirable crystalline silica for up to 10 hr/day during a 40-hr workweek over a working lifetime. The information presented in this document demonstrates that underground and surface coal miners are at risk of developing simple coal workers' pneumoconiosis (CWP), progressive massive fibrosis (PMF), silicosis, and chronic obstructive pulmonary disease (COPD). Adherence to the recommendations in this document should prevent or greatly reduce the risk of adverse health effects in workers exposed to respirable coal mine dust and respirable crystalline silica. NIOSH recommends that preventive efforts be focused primarily on reducing worker exposures. Effective health and hazard surveillance and medical screening are also useful components of a comprehensive prevention effort.

## 1.1 DEFINITIONS

### 1.1.1 Miner or Coal Miner

"Miner" or "coal miner" refers to any individual working in a surface or underground coal mine (including any worker employed by a contractor) who is (1) engaged in the extraction and production process, or (2) regularly exposed to mine hazards, or (3) employed as a construction, maintenance, or service worker.

### 1.1.2 Ex-Miner

"Ex-miner" refers to any individual who was previously employed as a coal miner but who left coal mining for reasons including retirement, disability, lay-off, or other employment.

### 1.1.3 Coal Mine

"Coal mine" refers to "an area of land and all structures, facilities, machinery, tools, equipment, shafts, slopes, tunnels, excavations, and other property, real or personal, placed upon, under, or above the surface of such land by any person, used in, or to be used in, or resulting from, the work of extracting in such area bituminous coal, lignite, or anthracite from its natural deposits in the earth

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\*This document provides the current NIOSH REL for respirable crystalline silica because this substance is an important component of respirable coal mine dust [NIOSH 1974; NIOSH 1988b]. Evaluation of the health effects of respirable crystalline silica is beyond the scope of this document.

by any means or method, and the work of preparing the coal so extracted, and includes custom coal preparation facilities” [30 USC<sup>†</sup> 802(h)(2)].

#### 1.1.4 Mine Operator

Except where otherwise indicated, a “mine operator” is any owner, lessee, or other person who operates, controls, or supervises a surface or underground coal mine, or any independent contractor performing services or construction at such a mine [30 USC 802(d)].

#### 1.1.5 Surface Coal Mine

“Surface coal mine” refers to “a surface area of land and all structures, facilities, machinery, tools, equipment, excavations, and other property, real or personal, placed upon or above the surface of such land by any person, used in, or to be used in, or resulting from, the work of extracting in such area bituminous coal, lignite, or anthracite from its natural deposits in the earth by any means or method, and the work of preparing the coal so extracted, including custom coal preparation facilities” [30 CFR<sup>‡</sup> 71.2(n)].

#### 1.1.6 Surface Work Area of an Underground Coal Mine

“Surface work area of an underground coal mine” refers to “the surface areas of land and all structures, facilities, machinery, tools, equipment, shafts, slopes, excavations, and other property, real or personal, placed in, upon or above the surface of such land by any person, used in, or to be used in, or resulting from, the work of extracting bituminous coal, lignite, or anthracite from its natural deposits underground by any means or method, and the work of preparing the coal so extracted, including custom coal preparation facilities” [30 CFR 71.2(p)].

### 1.2 RECOMMENDED EXPOSURE LIMITS (RELS) FOR RESPIRABLE COAL MINE DUST AND RESPIRABLE CRYSTALLINE SILICA

#### 1.2.1 RELs

NIOSH recommends that exposures to respirable coal mine dust be limited to 1 mg/m<sup>3</sup> as a time-weighted average (TWA) concentration for up to 10 hr/day during a 40-hr workweek<sup>§</sup>, measured according to current MSHA methods (see Section 5.1 and Appendix J). NIOSH recommends that sampling be conducted with a device that operates in accordance with the NIOSH accuracy criteria [Busch 1977; Busch and Taylor 1981] and the international definition of respirable dust [ACGIH 1994; CEN 1993; ISO 1993; Soderholm 1991a,b; 1989].\*\*

The recommended exposure limit (REL) of 1 mg/m<sup>3</sup> represents the upper limit of exposure for each worker during each work shift. For single, full-shift samples used to determine noncompliance,

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<sup>†</sup>United States Code.

<sup>‡</sup>Code of Federal Regulations. See CFR in references.

<sup>§</sup>A method for estimating an exposure limit “reduction factor” for extended work shifts is described by Brief and Scala [1975].

\*\*The recommended exposure limit (REL) of 1 mg/m<sup>3</sup> is equivalent to 0.9 mg/m<sup>3</sup> when measured according to these NIOSH recommended sampling criteria (see Sections 5.2 and 5.4).

NIOSH recommends that MSHA make no upward adjustment of the REL to account for measurement uncertainties [NIOSH 1994c] (see also Section 5.6.2).

Occupational exposures to respirable crystalline silica shall not exceed 0.05 mg/m<sup>3</sup> as a TWA concentration for up to 10 hr/day during a 40-hr workweek [NIOSH 1974; NIOSH 1988b].

## **1.2.2 Sampling and Analysis**

The concentration of respirable coal mine dust shall be determined gravimetrically (see Appendices I and J). The concentration of respirable crystalline silica shall be determined by NIOSH Method 7500, 7602, or a demonstrated equivalent [NIOSH 1994b] (see also Section 5.7).

## **1.3 EXPOSURE MONITORING**

### **1.3.1 Initial Exposure Monitoring Survey**

When a new mechanized mining unit (MMU) is established, the mine operator shall conduct an initial monitoring survey to determine the exposure of miners to respirable coal mine dust and respirable crystalline silica. The production level during sampling shall be typical of the normal production for that MMU (see Sections 5.5.3 and 5.6.1.4). Whenever changes in operational conditions might result in exposure concentrations above the REL, air sampling shall be conducted by the mine operator as if it were an initial monitoring survey.

### **1.3.2 Periodic Exposure Monitoring**

Personal exposures to respirable coal mine dust and respirable crystalline silica shall be monitored periodically at intervals that depend on the concentrations determined in the initial and subsequent monitoring surveys. For occupations in which worker exposures are found to exceed the REL for respirable coal mine dust or the REL for respirable crystalline silica (see Section 1.2.1), exposures shall be monitored as frequently as necessary to demonstrate that exposures have been controlled. See Section 5.6 for further discussion and recommendations for exposure monitoring.

### **1.3.3 Sampler Performance Criteria**

Worker exposures shall be compared with the RELs for respirable coal mine dust and respirable crystalline silica using single, full-shift samples collected with a sampling device that operates in accordance with the NIOSH accuracy criteria [Busch 1977; Busch and Taylor 1981] and the international definition of respirable dust [ACGIH 1994; CEN 1993; ISO 1993; Soderholm 1991a,b; 1989] (see Section 5.2).

### **1.3.4 Worker Notification**

A worker exposed to respirable coal mine dust or respirable crystalline silica at concentrations above the REL shall be notified of the exposure and of the control measures being implemented to reduce exposures.

### **1.3.5 Intake Air Concentrations**

Intake air concentrations of respirable coal mine dust and respirable crystalline silica shall be kept sufficiently below the RELs to provide effective dilution of respirable dust concentrations and to keep worker exposures below the RELs.

## **1.4 MEDICAL SCREENING AND SURVEILLANCE PROGRAM FOR UNDERGROUND AND SURFACE COAL MINERS**

### **1.4.1 General**

All medical examinations and procedures shall be performed by or under the direction of a licensed physician or other qualified health care provider at NIOSH-approved facilities. The mine operator shall ensure that miners can participate in the medical screening and surveillance program at a reasonable time and place without loss of pay or other cost to the miner.

### **1.4.2 Preplacement and Periodic Medical Examinations**

The Coal Workers' X-Ray Surveillance Program is administered by NIOSH and was established under the Federal Coal Mine Health and Safety Act of 1969 [Public Law 91-73].<sup>††</sup> Under this program, underground coal mine operators are required to provide periodic chest X-rays to underground coal miners and workers at surface work areas of underground coal mines. The specifications for giving, interpreting, classifying, and submitting the chest X-rays<sup>‡‡</sup> required for this program are contained in 42 CFR 37. See Section 6.2.1 for a more detailed description of this program. NIOSH recommends that surface coal miners be included in the Coal Workers' X-Ray Surveillance Program with the same provisions established for underground coal miners.

In addition to the periodic chest X-ray, NIOSH recommends that the Coal Workers' X-Ray Surveillance Program be extended to include spirometric examination both at the initial (preplacement) medical examination and at the intervals specified below. The purpose of spirometric examination is to detect unusual decrements in lung function and to permit timely intervention in the development of COPD.

The recommended components of the revised medical screening and surveillance program for underground and surface coal miners include the following:

- An initial (preplacement) spirometric examination and chest X-ray as soon as possible after beginning employment (within 3 months for a spirometric examination and within 3 to 6 months for a chest X-ray)
- A spirometric examination each year for the first 3 years after beginning employment and every 2 to 3 years thereafter if the miner is still engaged in coal mining

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<sup>††</sup>The 1969 Act was later amended by the Federal Mine Safety and Health Act of 1977 [30 USC 843].

<sup>‡‡</sup>Also called radiographs or roentgenograms.

- A chest X-ray every 4 to 5 years for the first 15 years of employment and every 3 years thereafter if the miner is still engaged in coal mining
- A chest X-ray and spirometric examination when employment ends if more than 6 months have passed since the last examination
- A standardized respiratory symptom questionnaire, such as the American Thoracic Society (ATS) respiratory questionnaire [Ferris 1978 (or the most current equivalent)], to be administered at the preplacement examination and updated at each periodic examination
- A standardized occupational history questionnaire (including a listing of all jobs held up to and including present employment, a description of all duties and potential exposures, and a description of all protective equipment the miner has used or may be required to use) to be administered at the preplacement examination and updated at each periodic examination

Information about the interpretation of chest X-rays and spirometric examinations and about medical intervention procedures is provided in Section 6.4.

## 1.5 POSTING

All warning signs shall be printed in both English and the predominant language of non-English-reading workers. Workers unable to read the posted signs shall be informed verbally about the hazardous areas of the mine and the instructions printed on the signs.

If respiratory protection is required, the following statement shall be posted:

**RESPIRATORY PROTECTION REQUIRED IN THIS AREA**

## 1.6 ENGINEERING CONTROLS AND WORK PRACTICES

The mine operator shall use engineering controls and work practices to keep worker exposures at or below the RELs for respirable coal mine dust and respirable crystalline silica. Chapter 8 and Appendices C and D describe available engineering controls and work practices.

## 1.7 RESPIRATORY PROTECTION

### 1.7.1 General Considerations

Respirators shall be used when engineering controls and work practices are not effective in maintaining worker exposures at or below the RELs for respirable coal mine dust and respirable crystalline silica. Respirators may be used as an interim<sup>§§</sup> control measure, but they shall not be used in lieu of

<sup>§§</sup>Interim use periods shall meet one or more of the three conditions listed in Section 8.6.2.1.

feasible engineering controls and work practices. Whenever respirators are used, the mine operator shall institute a respiratory protection program conforming to the recommendations in Chapter 8.

### 1.7.2 Respiratory Protection Program

This program shall include, at a minimum, the following elements:

- A designated individual responsible for the administration of the program
- A written program for respiratory protection that contains standard operating procedures governing the selection and use of respirators
- Initial and annual training of workers in the proper use and limitations of respirators as required in 30 CFR 48.28 and 48.31
- Annual training of persons whose jobs require them to be certified at underground coal mines in the use of self-contained, self-rescue devices as required in 30 CFR 75.161
- Evaluation of working conditions in the mines (including periodic air monitoring of worker exposures) to identify situations that require respiratory protection
- Routine inspection, cleaning, maintenance, and proper storage of respirators according to the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987a]
- Initial quantitative fit testing by a trained and qualified person to determine the level of protection provided by each respirator worn (for a description of qualitative fit testing, see the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987a])
- Additional daily fit checks conducted by the worker to ensure proper assembly, function, and face-seal integrity of the respirator
- Medical evaluation of the worker's physical ability to perform work continuously while breathing through a respirator [Appendix H of NIOSH 1991b; NIOSH 1994d]
- Periodic evaluation of program effectiveness through the monitoring of respirator use patterns, quarterly inspection of the respirator maintenance program, and testing of supervisors and workers for awareness of respirator use requirements

### 1.7.3 Respirator Selection

Respirators shall be selected by a qualified person according to the guidelines in Section 8.5.2.2 of this criteria document and the most recent edition of the *NIOSH Respirator Decision Logic* [NIOSH 1987b]. Only respirators approved by NIOSH and the Mine Safety and Health Administration (MSHA) shall be used.

## **1.8 INFORMING WORKERS OF THE HAZARDS**

### **1.8.1 Notification of Hazards**

The mine operator shall provide all miners with information about workplace hazards before job assignment and at least annually thereafter.

### **1.8.2 Training**

The mine operator shall institute a continuing education program conforming to the requirements in 30 CFR 48. The purpose of this program is to ensure that all miners have a current knowledge of workplace hazards (e.g., respirable coal mine dust and respirable crystalline silica), effective work practices, engineering controls, and the proper use of respirators and other personal protective equipment. The continuing education program shall also include a description of the exposure monitoring and medical surveillance programs and the advantages of participating in them. This information shall be kept on file and shall be readily available to miners for examination and copying. The mine operator shall maintain a written plan of these training programs and a written record of the miners' attendance at such programs (including dates).

Miners shall be instructed about their responsibilities for following proper work practices and sanitation procedures necessary to protect their health and safety.

## **1.9 SANITATION AND HYGIENE**

### **1.9.1 Smoking**

Smoking shall be prohibited in all underground and surface coal mines and all other work areas associated with coal mining. MSHA currently prohibits smoking in all underground mines and in surface coal mines where fire or explosion may result [30 CFR 75.1072 and 77.1711]. In addition, NIOSH recommends that smoking be prohibited to prevent exposure to environmental tobacco smoke, a potential occupational carcinogen [NIOSH 1991a].

### **1.9.2 Drinking Water**

An adequate supply of potable water shall be provided for workers at each underground worksite [30 CFR 75.1718] and each surface worksite [30 CFR 71.600-71.603].

### **1.9.3 Showering, Changing, and Toilet Facilities**

The mine operator shall provide workers with clean facilities for showering and changing clothes at the end of each work shift. Mine operators shall provide an adequate number of toilet facilities. The mine operator shall also provide storage facilities such as lockers to permit workers to store street clothing and personal items. Regulations for bath, toilet, and changing facilities are provided in 30 CFR 71.400-71.501 for surface worksites, and in 30 CFR 75.1712 for underground worksites.

## **1.10 RECORDKEEPING**

### **1.10.1 Records of Exposure Monitoring**

Records related to the exposure monitoring required in Section 1.3 shall be retained by the mine operator or by MSHA, as applicable, for at least 40 years after termination of employment.

### **1.10.2 Medical Records**

NIOSH-held records related to the medical screening and surveillance program in Section 1.4 shall be maintained by NIOSH in accordance with 42 CFR 37.80. Any medical records that the mine operator may have as part of a medical program for coal miners shall be retained by the mine operator for at least 40 years after termination of employment.

### **1.10.3 Availability of Records**

The miner shall have access to his medical records and be permitted to obtain copies. Records shall also be made available to former miners or their representatives and to the designated representatives of the Secretary of Labor and the Secretary of Health and Human Services.

### **1.10.4 Transfer of Records**

Exposure monitoring and medical records shall be transferred as follows:

- Upon termination of employment, the mine operator shall provide the miner with a copy of his records related to exposure monitoring and medical screening and surveillance.
- Whenever the mine operator transfers ownership of the mine, all records described in this section shall be transferred to the new operator, who shall maintain them as required by this standard.
- Whenever a mine operator ceases to do business and there is no successor, the mine operator shall notify the miners of their rights of access to those records at least 3 months before cessation of business.
- Before a mine operator disposes of records or ceases to do business without a successor to maintain records, the mine operator shall notify the Director of NIOSH in writing. No records shall be destroyed until the Director of NIOSH responds in writing to the mine operator.
- After informing the Director of NIOSH of impending disposal or lack of successor to maintain records, the mine operator shall transfer custody of records to NIOSH if the Director of NIOSH or a designee requests it.

## 2 INTRODUCTION

### 2.1 PURPOSE

This document presents the criteria and recommended standards necessary to reduce or eliminate health impairment from exposure to respirable coal mine dust. The document was developed in accordance with the Federal Mine Safety and Health Act of 1977 [30 USC 811 and 842(d)]<sup>\*</sup> and the Occupational Safety and Health Act of 1970 [29 USC 20(a)(3) and 22(c)(1)]. In these Acts, NIOSH is charged with recommending occupational safety and health standards and developing criteria for toxic materials and harmful physical agents. These criteria are to describe exposures that are safe for various periods of employment—including (but not limited to) the exposures at which no worker will suffer diminished health, functional capacity, or life expectancy as a result of his or her work experience.

NIOSH has formalized a system for developing criteria on which to base standards for ensuring the health and safety of workers exposed to hazardous chemical and physical agents. Simple compliance with these standards is not the only goal. The criteria and recommended standards are also intended to help management and labor develop better engineering controls and more healthful work practices.

Recommended standards for respirable coal mine dust apply to workplace exposures arising from the extraction, processing, and use of coal. The recommended standards are intended to protect workers from the chronic effects of exposure to respirable coal mine dust. Exposures are measurable by techniques that are valid, reproducible, and available to industry and government agencies. Recommendations in this document pertain to existing regulations in 30 CFR 48, 70, 71, 74, 75, 77, and 90, and in 42 CFR 37.

### 2.2 SCOPE

The information in this document is used to assess the hazards associated with occupational exposure to respirable coal mine dust. Epidemiological studies from the United States and abroad have shown that underground and surface coal miners are at risk of developing simple CWP, PMF, silicosis, and COPD. PMF and advanced stages of silicosis and COPD are associated with respiratory impairment, disability, and premature death.

Chapter 1 presents the recommended standards and describes their requirements. Chapter 3 contains information about the chemical and physical properties of respirable coal mine dust, production

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<sup>\*</sup>This act amended the Federal Coal Mine Health and Safety Act of 1969 [Public Law 91-173].

methods, uses, and the extent of worker exposure. Chapter 4 discusses the health effects of exposures to respirable coal mine dust. Chapter 5 addresses environmental monitoring, and Chapter 6 describes the recommended medical screening and surveillance program for underground and surface coal miners. Chapter 7 discusses the basis for the recommended standard for respirable coal mine dust. Chapter 8 describes methods for worker protection, and Chapter 9 lists research needs. The appendices include tables of exposures to respirable coal mine dust by occupation; methods for controlling respirable dust in underground and surface coal mines; technical aspects of spirometric examinations, spirometry reference values, and the occupational history questionnaire; and technical analyses of sampling criteria, exposure variability, and validation of risk estimates.

## **2.3 NIOSH ACTIVITIES AND PROGRAMS FOR COAL MINERS**

In addition to recommending occupational safety and health standards under the Federal Mine Safety and Health Act of 1977 [30 USC 811], NIOSH is responsible for several activities related to coal miners:

- Conducting epidemiological research to
  - identify and define factors involved in occupational diseases of miners,
  - provide information about the incidence and prevalence of pneumoconiosis and other respiratory ailments of miners, and
  - improve mandatory health standards [30 USC 951(a)(5)]
- Prescribing the specifications for giving, reading, and classifying chest X-rays and any other medical tests NIOSH deems necessary [30 USC 843(a)]
- Providing for the autopsy of miners with the consent of the surviving spouse or the next of kin [30 USC 843(d)]
- Approving respiratory equipment [30 USC 842(h)]
- Certifying coal mine dust sampling units [30 USC 842(e)]

Under the Black Lung Benefits Act of 1981 [30 USC 901-945], NIOSH is to provide criteria for medical tests that accurately reflect total disability in coal miners [30 USC 902(f)]. A discussion of the Black Lung Benefits Program is provided in Appendix H.

## **2.4 HEALTH EFFECTS STUDIES**

Numerous U.S. and foreign studies show that miners exposed to respirable dust in underground coal mines over a working lifetime are at risk of developing simple CWP and PMF [Attfield and Seixas 1995; Attfield and Moring 1992b; Maclaren et al. 1989; Hurley et al. 1987; Hurley et al. 1982; Shennan et al. 1981]. Miners who show evidence of the higher radiographic categories of simple

CWP are at increased risk of developing PMF. The current U.S. standard of  $2 \text{ mg/m}^3$  for respirable coal mine dust [30 USC 801-962; 30 CFR 70 and 71] is based primarily on estimates of early studies of coal miners in the United Kingdom [Jacobsen et al. 1971; McLintock et al. 1971; Cochrane 1962]. The intent of the standard of  $2 \text{ mg/m}^3$  is to prevent the development of PMF by preventing progression of simple CWP to category 2 or greater.

More recent studies from the United States and the United Kingdom indicate that the risk of PMF is higher than estimated in the studies used as the basis for the current U.S. coal dust standard [Attfield and Seixas 1995; Attfield and Moring 1992b; Hurley and Maclaren 1987; Hurley et al. 1987]. These U.S. and U.K. studies have shown that the prevalence of simple CWP and PMF has been declining since the 1960s [British Coal Corporation 1993; Attfield and Castellan 1992; Attfield and Althouse 1992]. However, simple CWP and PMF have not been eliminated under the current standard. Estimates indicate that at age 58, an average of 7/1,000 U.S. workers (exposed to low-rank coal) and 89/1,000 U.K. workers (exposed to high-rank coal) will have developed PMF during 40 years of exposure to respirable dust at a mean concentration of  $2 \text{ mg/m}^3$  [Attfield and Seixas 1995; Attfield and Moring 1992b; Hurley and Maclaren 1987]. Within this range, the higher disease prevalences are predicted for U.S. miners and for U.S. and U.K. miners exposed to the dust of higher-ranked coal.

Studies from the United States and abroad have also shown that coal miners are at increased risk of developing COPD, whether or not simple CWP or PMF is present [Seixas et al. 1993, 1992; Attfield and Hodous 1992; Soutar et al. 1988; Marine et al. 1988; Soutar and Hurley 1986; Rogan et al. 1973]. Studies of surface coal miners have shown that they are also at risk of developing simple CWP [Love et al. 1992; Amandus et al. 1989, 1984].

## 2.5 OTHER STANDARDS AND RECOMMENDATIONS

### 2.5.1 MSHA

The current Federal standard of  $2 \text{ mg/m}^3$  for respirable dust in the mine atmosphere was established by the Federal Coal Mine Health and Safety Act of 1969 [P.L. 91-173], which was amended by the Federal Mine Safety and Health Act of 1977 [30 USC 801-962]. An interim standard of  $3 \text{ mg/m}^3$  was in effect from 1969 to 1972 [30 USC 842 (b)], when the current standard became effective. MSHA of the U.S. Department of Labor was established under the Federal Mine Safety and Health Act of 1977 [30 USC 801-962]. MSHA is responsible for enforcing the provisions of the Act, including the establishment of safety and health regulations [30 CFR 70 and 71]. Two Federal agencies preceded MSHA: the Mine Enforcement and Safety Administration (MESA) of the U.S. Department of the Interior (from 1972 to 1977) and the U.S. Bureau of Mines Inspection Division (before 1972).

MSHA has adopted a permissible exposure limit (PEL) of  $2 \text{ mg/m}^3$  for respirable coal mine dust, which is measured gravimetrically as an 8-hour TWA concentration of the respirable coal mine dust. The applicable standard for respirable coal mine dust is reduced when the respirable quartz content exceeds 5% (a formula of 10 divided by the percentage of respirable quartz is used to determine the reduced PEL for respirable coal mine dust) [30 CFR 70.101 and 71.101]. Thus, the

MSHA PEL for respirable quartz ( $0.1 \text{ mg/m}^3$ ) corresponds to a respirable coal mine dust concentration of  $2 \text{ mg/m}^3$  and a quartz content of 5%.

Coal mine operators are required to take bimonthly samples of airborne respirable dust in the active workings of a coal mine with a device approved by the Secretary of the U.S. Department of Labor and the Secretary of the U.S. Department of Health and Human Services [30 CFR 70.206, 71.206, and 74]. The measured concentration is multiplied by a conversion factor of 1.38 to adjust for differences in sampling devices used in the United States (a 10-mm nylon cyclone) and the United Kingdom (a horizontal elutriator developed by the British Mining Research Establishment [MRE]) [Tomb et al. 1973]. The respirable particulate size fraction is defined by the British Medical Research Council criterion for particle-size selective dust samplers as “100% efficiency at 1 micron or below, 50% at 5 microns, and zero efficiency for particles of 7 microns and upwards” [ATC 1970; Orenstein 1960].

### **2.5.2 OSHA**

OSHA has adopted a PEL of  $2 \text{ mg/m}^3$  for the respirable dust fraction containing less than 5% quartz and a PEL of  $0.1 \text{ mg/m}^3$  for the respirable quartz fraction of coal dust containing 5% or more quartz. Both OSHA PELs are 8-hr TWAs.

### **2.5.3 ACGIH TLV**

The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) for respirable coal mine dust is  $2 \text{ mg/m}^3$  as a TWA.

### **2.5.4 WHO Exposure Limit**

The World Health Organization (WHO) [WHO 1986] has recommended a “tentative health-based exposure limit” for respirable coal mine dust (with <7% respirable quartz) ranging from 0.5 to  $4.0 \text{ mg/m}^3$ . WHO recommended that this limit be based on (1) the risk factors (i.e., coal rank or carbon content, proportion of respirable quartz and other minerals, and particle size distribution of the coal dust) for CWP category 1 that are determined at each mine, and (2) the assumption that the risk of PMF over a working lifetime (56,000 hr) will not exceed 2/1,000. Based on the WHO approach, the risk of disease would be determined separately for each individual mine or group of mines, and the exposure limit would vary from mine to mine.

### **2.5.5 Limits in Other Countries**

Table 2-1 lists occupational exposure limits for respirable coal mine dust and respirable crystalline silica in various countries. Exposure limits cannot be directly compared from country to country because of differences in measurement strategies. Prinz and Stolz [1990] describe differences in the sampling locations within the mines and differences in the number of samples and the frequency of sampling in various countries. Measurements in the United States have been compared with those in the United Kingdom by applying the MRE conversion factor (Section 2.5.1).

**Table 2-1. Occupational exposure limits for respirable coal mine dust and respirable crystalline silica in various countries**

Country	Recommended value (gravimetric)	Comment
Australia*	3 mg/m <sup>3</sup>	Coal dust with ≤5% respirable free silica
Belgium	$\frac{10 \text{ mg/m}^3}{\% \text{ respirable quartz} + 2}$	
Brazil	$\frac{8 \text{ mg/m}^3}{\% \text{ respirable quartz} + 2}$	
Finland	2.0 mg/m <sup>3</sup> 0.2 mg/m <sup>3</sup> 0.1 mg/m <sup>3</sup>	Coal dust Quartz (fine dust <5 μm) Silica: cristobalite, tridymite
Federal Republic of Germany †	0.15 mg/m <sup>3</sup> 4.0 mg/m <sup>3</sup>	Quartz (including cristobalite and tridymite) Fine dust containing quartz (1% or greater quartz by weight)
Italy	3.33 mg/m <sup>3</sup>	Coal dust with <1% quartz
	$\frac{10 \text{ mg/m}^3}{q + 3}$ where q = % of quartz (mass)	Coal dust with >1% quartz
Netherlands	2 mg/m <sup>3‡</sup> 0.075 mg/m <sup>3</sup>	Coal dust (less than 5% respirable quartz) Silica: cristobalite, tridymite
Sweden	0.05 mg/m <sup>3</sup>	Silica: cristobalite, tridymite
United Kingdom§	3.8 mg/m <sup>3</sup>	Coal mine dust (average concentration at the coal face)
United States (MSHA)	2.0 mg/m <sup>3</sup>	Coal dust with <5% silica
	$\frac{10 \text{ mg/m}^3}{\% \text{ SiO}_2}$	Coal dust with >5% silica
	$\frac{10 \text{ mg/m}^3}{\% \text{ respirable quartz} + 2}$	Silica: quartz
	Half of the value for quartz	Silica: cristobalite, tridymite
Yugoslavia	4 mg/m <sup>3</sup>	Fine dust with <2% free crystalline silica
	$\frac{0.07 \times 100 \text{ mg/m}^3}{\% \text{ FCS}}$	Fine dust with >2% free crystalline silica
	0.07 mg/m <sup>3</sup>	Pure quartz (fine dust)

Source: WHO [1986] (except as otherwise noted).

\*Source: Coal Mines Regulation Act 1982 (New South Wales); Coal Mines Regulation, Respirable Dust 1978 (Queensland).

†Source: German Research Institute [1992].

‡Source: Cook [1987].

§Source: Jacobsen [1984]. Recommended value is based on maximum allowable concentration of 7 mg/m<sup>3</sup> in the return airway during the working shift.